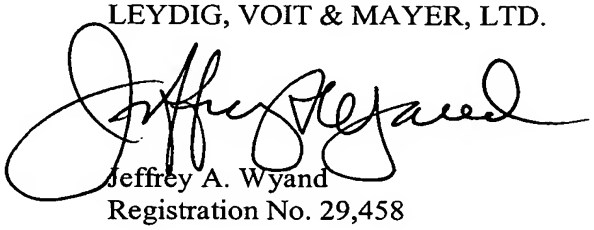
**REMARKS**

The foregoing Amendment corrects translational errors and conforms the claims to United States practice. No new matter is added.

Respectfully submitted,

LEYDIG, VOIT & MAYER, LTD.



Jeffrey A. Wyand
Registration No. 29,458

Suite 300
700 Thirteenth Street, N.W.
Washington, D.C. 20005
Telephone: (202) 737-6770
Facsimile: (202) 737-6776
Date: December 11, 2001
JAW:ves

**PATENT**
Attorney Docket No. 401479/AOYAMA

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

In re Application of:

IZUO et al.

Application No. Unknown

Art Unit: Unknown

Examiner: Unknown

Filed: December 11, 2001

For: ELECTROCHEMICAL ETCHING METHOD AND APPARATUS AND PRODUCT MANUFACTURED THEREBY

## AMENDMENTS TO SPECIFICATION, CLAIMS AND ABSTRACT MADE VIA PRELIMINARY AMENDMENT

*Amendments to the paragraph beginning at page 1, line 5*:

The present invention relates to an electrochemical etching method and apparatus. In particular, the present invention relates to a method and apparatus in which an n-type silicon substrate is exposed at ~~its~~ one surface to an electrolyte and at ~~its~~ an opposite surface to light, so that ~~the substrate is formed with~~ a pore (hole) or a trench (groove) of a certain size and shape ~~as~~ is formed in the substrate as an etching current flowing in the substrate is controlled by the light. Also, the present invention relates to a product, e.g., a semiconductor device, made by the use of the electrochemical etching method. It is to be understood that the present invention is preferably applicable to a method and apparatus for ~~an~~ electrochemical etching for the formation of pores or trenches having a diameter or width of 50nm or more in the n-type silicon substrate. However, the present invention is not limited by the size of the pore or trench.

*Amendments to the paragraph beginning at page 1, line 24*:

~~The~~ Japanese Patent Publication No. 2,694,731 discloses an electrochemical etching system which uses light to form small pores or trenches in an n-type doped silicon substrate. The system has a holder for holding the n-type doped silicon substrate (silicon wafer) with one surface of the substrate contacted with an electrolyte (~~hydrofluoricacid~~ hydrofluoric acid). Also, the holder retains an electrode in the electrolyte so that the electrode opposes ~~to~~ the silicon substrate. With this etching system, the silicon substrate is positively biased and

the electrode in the electrolyte is negatively biased. The opposite side of the silicon substrate away from the electrolyte is exposed to light, causing holes in the silicon substrate. The holes travel a boundary region ~~of~~ between the silicon substrate and the electrolyte to resolve the boundary portion of the silicon substrate. This means that an arrangement of a masking barrier (coating) with one or more apertures (pits) on the surface of the silicon substrate~~,~~ adjacent to the electrolyte, results in the formation of the pores or trenches in the substrate portions, corresponding to the apertures.

*Amendments to the paragraph beginning at page 2, line 20*:

The Journal of Electrochemical Society, No. 140, October 1993, pp. 2836-2843 discloses a back light device for the illumination of a silicon substrate. The light device has a lamp for emitting light, an infrared filter for removing infrared light from the emitted light, and a convex lens for collimating the light emitted from the lamp.

*Amendments to the paragraph beginning at page 3, line 1*:

Also, the Journal of Electrochemical Society, No. 137, February 1990, pp. ~~2836-2843~~ 653-659 discloses an electrochemical etching device which uses a 100W tungsten lamp for the back light device.

*Amendments to the paragraph beginning at page 3, line 5*:

Further, ~~the~~ Japanese Patent Publication No. 11-509644 discloses a system for manufacturing devices with electrochemical etching ~~unit~~. ~~Another~~ Japanese Patent Publication No. 11-154737 discloses a manufacturing system for incorporating a capacitance in the trench formed by the electrochemical etching technique. ~~Besides, the~~ The Journal of Electrochemical Society, No. 137, February 1990, pp. 653-659 discloses an embodiment in which an aperture or trench of 20 x 20 mm is formed in the silicon substrate by the etching technique.

*Amendments to the paragraph beginning at page 4, line 9*:

Another object of the present invention is to provide devices, e.g., semiconductor ~~device~~ devices and sensors, such as acceleration ~~sensor~~ sensors, manufactured through such electrochemical etching method.

*Amendments to the paragraph beginning at page 10, line 21*:

Fig. 4 is an enlarged cross sectional view taken along lines ~~V-V~~ IV-IV in Fig. 3, showing the grid electrode layer in an exaggerated fashion;

*Amendments to the paragraph beginning at page 11, line 14*:

~~Fig. 10 is~~Figs. 10A and 10B are a schematic plan view and a detail view of the grid electrode plate for use in the electrochemical etching system according to the seventh embodiment;

*Amendments to the paragraph beginning at page 27, line 18*:

Although in the first embodiment the grid metal layer is integrally formed on the back surface of the silicon substrate, it may be formed as an independent member capable of being separated from the silicon wafer. Specifically, Fig. ~~10~~ 10A shows a grid metal plate 140 made of an electrically conductive material and Fig. 10B shows a detail view of the grid metal plate. Preferably, as described above, the size of the grid 142 and of the ~~opening~~ openings 144 in the grid metal plate 140 are determined so that the size of the grid 142 is smaller than the thickness of the silicon substrate.

*Amendments to existing claims*:

1. (Amended) An electrochemical etching system, comprising:

an etching bath for holding an n-type silicon substrate so that ~~one~~ a first surface of said silicon substrate contacts ~~with hydrofluoricacid~~ hydrofluoric acid;

an electrode positioned in ~~said hydrofluoricacid~~ the hydrofluoric acid;

a power source having a positive ~~polarity and a negative polarity, said positive polarity being~~ terminal connected to ~~said~~ the silicon substrate and ~~said~~ a negative ~~polarity being~~ terminal connected to ~~said~~ the electrode; and

an illumination unit having a light source for ~~an~~ illumination of ~~the other~~ a second surface of ~~said~~ the silicon substrate~~, wherein light source illuminates said the other surface of said silicon substrate~~ with an illumination intensity of at least $10mW/cm^2$ ~~or more~~.

2. (Amended) ~~An~~ The electrochemical etching system in accordance with claim 1, wherein a ratio of a maximum illumination to a minimum illumination ~~to said~~ of the ~~other~~ second surface of the silicon substrate is no more than 1.69:1 ~~or less~~.

3. (Amended) ~~An~~ The electrochemical etching system in accordance with claim 1~~or 2~~, further~~comprises~~ comprising:

a reference electrode positioned in~~said hydrofluoricacid~~ the hydrofluoric acid; and

a voltage meter electrically connected between said reference electrode and~~said~~ the silicon substrate~~, said voltage meter having an elevated impedance~~.

4. (Amended) ~~An~~ The electrochemical etching system in accordance with~~any one of claims~~ claim 1~~to 3~~, wherein said illumination unit has an illumination controller for controlling~~said~~ the illumination of~~said~~ the~~other~~ second surface of~~said~~ the silicon substrate.

5. (Amended) ~~An~~ The electrochemical etching system in accordance with claim 4, wherein said illumination controller controls~~an amount~~ quantity of light emitted from said light source.

6. (Amended) ~~An~~ The electrochemical etching system in accordance with claim 4, wherein said illumination controller has a modulator, said modulator being connected between said light source and~~said~~ the silicon substrate for modulating~~said~~ the light emitted from said light source.

7. (Amended) ~~An~~ The electrochemical etching system in accordance with~~any one of claims~~ claim 4~~to 6~~, further~~comprises~~ comprising:

a current detector for detecting an electric current~~applied~~ supplied from said power source to~~said~~ the silicon substrate; and

an electric circuit for controlling~~said amount~~ quantity of~~said~~ the light emitted from said light source based upon~~said~~ the electric current detected by said current detector.

8. (Amended) ~~An~~ The electrochemical etching system in accordance with~~any one of claims~~ claim 1~~to 7~~, further~~comprises~~ comprising a unit for retaining a stable quality of~~said hydrofluoricacid~~ the hydrofluoric acid.

9. (Amended) ~~An~~ The electrochemical etching system in accordance with~~any one of claims~~ claim 1~~to 8~~, further~~comprises~~ comprising a metal plate positioned on~~said~~ the~~other~~ second surface of~~said~~ the silicon substrate, said metal plate having a~~number~~ plurality of openings arranged~~regularly~~ uniformly for transmitting the light~~which has been~~ emitted from said illumination unit toward~~said~~ the~~other~~ second surface of~~said~~ the silicon substrate.

10. (Amended) ~~An~~ The electrochemical etching system in accordance with claim 9, wherein said metal plate is ~~made of~~ electrically conductive ~~material~~ and mounted on ~~said~~ the ~~other~~ second surface of ~~said~~ the silicon substrate.

11. (Amended) ~~An~~ The electrochemical etching system in accordance with claim 10, wherein said metal plate is integrally formed on ~~said~~ the ~~other~~ second surface of ~~said~~ the substrate.

12. (Amended) ~~An~~ The electrochemical etching system in accordance with claim 10, wherein said metal plate is independently formed on ~~said~~ the ~~other~~ second surface of ~~said~~ the substrate.

13. (Amended) ~~An~~ The electrochemical etching system in accordance with ~~any one of claims~~ claim 9 ~~to 12~~, wherein a part of said metal plate remaining between neighboring openings has a width ~~which is equal to or less~~ larger than a thickness of ~~said~~ the silicon substrate.

14. (Amended) An electrochemical etching method ~~having the steps of making one~~ comprising:

placing a first surface of an n-type silicon substrate ~~into~~ in contact with an electrolyte,

illuminating ~~the other~~ a second surface of ~~said~~ the silicon substrate with an illumination intensity of at least 10mW/cm$^2$, and

controlling an etching current ~~by said~~ with the illumination of the second surface to form a pore or trench in ~~said one~~ the first surface of ~~said~~ the silicon substrate~~, characterized in that~~

~~the method further comprises~~

~~illuminating said the other surface of said silicon substrate with an illumination of 10mW/cm$^2$ or more~~.

15. (Amended) ~~An~~ The electrochemical etching method in accordance with claim 14, further ~~comprises~~ comprising:

arranging a metal plate on ~~said~~ the ~~other~~ second surface of ~~said~~ the silicon substrate, ~~said~~ the metal plate having a ~~number~~ plurality of openings arranged ~~regularly~~ uniformly; and

illuminating ~~said~~ the ~~other~~ second surface of ~~said~~ the n-type silicon through ~~said~~ the openings.

16. (Amended) ~~An~~ The electrochemical etching method in accordance with claim 14, wherein a ratio of a maximum illumination to a minimum illumination ~~to said~~ of the ~~other~~ second surface of the silicon substrate is no more than 1.69:1 ~~or less~~.

17. (Amended) An electrochemical etching method ~~having the steps of making one~~ comprising:

placing a first surface of an n-type silicon substrate ~~into~~ in contact with an electrolyte~~;~~;

illuminating ~~the other~~ a second surface of ~~said~~ the silicon substrate with a first illumination intensity of at least 10mW/cm$^2$, ~~and~~

controlling an etching current ~~by said~~ with the illumination of the second surface to form pores or trenches in ~~said one~~ the first surface of ~~said~~ the silicon substrate~~, characterized in that~~

~~the method further comprises~~

~~a first step in which said the other surface of said silicon substrate is illuminated with a first illumination of 10mW/cm$^2$ or more to form said pores or trenches~~ extending toward ~~said~~ the ~~other~~ second surface of ~~said~~ the silicon substrate; and

~~a second step in which, after said first step, said~~thereafter illuminating the ~~other~~ second surface of ~~said~~ the silicon substrate ~~is illuminated~~ with ~~another~~ a second illumination intensity, higher than ~~said~~ the first illumination intensity, to extend ~~said~~ the pores or trenches laterally to connect ~~said~~ the pores or trenches to each other.

18. (Amended) A product manufactured by ~~said~~ the electrochemical etching method in accordance with ~~any one of said claims~~ claim 14 ~~to 16~~.

*Amendments to the abstract*:

ABSTRACT

An electrochemical etching system ~~(10)~~ has an etching bath ~~(12)~~ for holding an n-type silicon substrate ~~(20)~~ with ~~one~~ a first surface ~~(32)~~ of the substrate ~~being~~ in contact with ~~hydrofluoricacid (14)~~ hydrofluoric acid, an electrode ~~(28)~~ positioned in ~~hydrofluoricacid~~ the hydrofluoric acid, a power source ~~(30)~~ having a positive ~~polarity~~ pole connected to the silicon substrate and a negative ~~polarity~~ pole connected to the electrode, and an illumination unit ~~(52)~~ having a light source ~~(56)~~ for ~~an~~ illumination of ~~the other~~ a second surface ~~(38)~~ of the silicon substrate. The illumination unit illuminates the ~~other~~ second surface of the silicon substrate with an illumination intensity of 10mW/cm$^2$ or more. ~~Also, a~~ A ratio of a maximum illumination to a minimum illumination ~~to~~ of the ~~other~~ second surface of the silicon substrate

is ~~set~~ 1.69:1 or less. With the etching system, pores and/or trenches of a certain size and shape can be formed in an entire area of the silicon substrate ~~with~~ having a diameter of more than three inches.

**PATENT**
Attorney Docket No. 401479/AOYAMA

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

In re Application of:

IZUO et al.

Art Unit: Unknown

Application No. Unknown

Examiner: Unknown

Filed: December 11, 2001

For: ELECTROCHEMICAL ETCHING METHOD AND APPARATUS AND PRODUCT MANUFACTURED THEREBY

**PENDING CLAIMS AFTER ENTRY OF PRELIMINARY AMENDMENT**

1. An electrochemical etching system, comprising:

an etching bath for holding an n-type silicon substrate so that a first surface of said silicon substrate contacts hydrofluoric acid;

an electrode positioned in the hydrofluoric acid;

a power source having a positive terminal connected to the silicon substrate and a negative terminal connected to the electrode; and

an illumination unit having a light source for illumination of a second surface of the silicon substrate with an illumination intensity of at least $10mW/cm^2$.

2. The electrochemical etching system in accordance with claim 1, wherein a ratio of a maximum illumination to a minimum illumination of the second surface of the silicon substrate is no more than 1.69:1.

3. The electrochemical etching system in accordance with claim 1, further comprising:

a reference electrode positioned in the hydrofluoric acid; and

a voltage meter electrically connected between said reference electrode and the silicon substrate.

4. The electrochemical etching system in accordance with claim 1, wherein said illumination unit has an illumination controller for controlling the illumination of the second surface of the silicon substrate.

5. The electrochemical etching system in accordance with claim 4, wherein said illumination controller controls quantity of light emitted from said light source.

6. The electrochemical etching system in accordance with claim 4, wherein said illumination controller has a modulator, said modulator being connected between said light source and the silicon substrate for modulating the light emitted from said light source.

7. The electrochemical etching system in accordance with claim 4, further comprising:

a current detector for detecting an electric current supplied from said power source to the silicon substrate; and

an electric circuit for controlling quantity of the light emitted from said light source based upon the electric current detected by said current detector.

8. The electrochemical etching system in accordance with claim 1, further comprising a unit for retaining a stable quality of the hydrofluoric acid.

9. The electrochemical etching system in accordance with claim 1, further comprising a metal plate positioned on the second surface of the silicon substrate, said metal plate having a plurality of openings arranged uniformly for transmitting the light emitted from said illumination unit toward the second surface of the silicon substrate.

10. The electrochemical etching system in accordance with claim 9, wherein said metal plate is electrically conductive and mounted on the second surface of the silicon substrate.

11. The electrochemical etching system in accordance with claim 10, wherein said metal plate is integrally formed on the second surface of the substrate.

12. The electrochemical etching system in accordance with claim 10, wherein said metal plate is independently formed on the second surface of the substrate.

13. The electrochemical etching system in accordance with claim 9, wherein a part of said metal plate remaining between neighboring openings has a width larger than a thickness of the silicon substrate.

14. An electrochemical etching method comprising:

placing a first surface of an n-type silicon substrate in contact with an electrolyte,

illuminating a second surface of the silicon substrate with an illumination intensity of at least 10mW/cm$^2$, and

controlling an etching current with the illumination of the second surface to form a pore or trench in the first surface of the silicon substrate

15. The electrochemical etching method in accordance with claim 14, further comprising:

arranging a metal plate on the second surface of the silicon substrate, the metal plate having a plurality of openings arranged uniformly; and

illuminating the second surface of the n-type silicon through the openings.

16. The electrochemical etching method in accordance with claim 14, wherein a ratio of a maximum illumination to a minimum illumination of the second surface of the silicon substrate is no more than 1.69:1.

17. An electrochemical etching method comprising:

placing a first surface of an n-type silicon substrate in contact with an electrolyte;

illuminating a second surface of the silicon substrate with a first illumination intensity of at least 10mW/cm$^2$, controlling an etching current with the illumination of the second surface to form pores or trenches in the first surface of the silicon substrate extending toward the second surface of the silicon substrate; and

thereafter illuminating the second surface of the silicon substrate with a second illumination intensity, higher than the first illumination intensity, to extend the pores or trenches laterally to connect the pores or trenches to each other.

18. A product manufactured by the electrochemical etching method in accordance with claim 14.